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ABSTRACT

The recommendations of "Educating Americans for the 21st Century," a plan of action developed by the National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology, are discussed in this paper with special reference to their implications for two-year colleges. After outlining the main thesis of the report (i.e., the nation is failing to provide its children with the intellectual tools needed for the 21st century), the paper reviews the Commission's proposals for changing what is learned and how it is taught, through: (1) building a strong national commitment to quality education for all students; (2) providing earlier and increased exposure to math, science, and technical subjects; (3) providing a system to measure student participation and achievement; (4) retraining, attaining, and keeping quality teachers; (5) improving the quality and usefulness of the curriculum; (6) establishing exemplary programs in every community to serve as standards of excellence; (7) utilizing all available resources; and (8) establishing and meeting costs. After examining the detailed recommendations proposed by the Commission for meeting these objectives, the paper suggests the kinds of improvement and problems that may result for U.S. colleges if the elementary and secondary schools attain the goals set out in the Commission report; e.g., entering college freshmen will have greater math ability, yet the national shortage of math teachers will be exacerbated. (HB)

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MEETING THE CHALLENGE

Implications of

Educating Americans for the 21st Century

for Two-Year Colleges

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May 1984

JC 840 530

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MEETING THE CHALLENGE,

IMPLICATIONS OF

EDUCATING AMERICANS FOR THE 21st CENTURY

FOR TWO-YEAR COLLEGES

Not since the Russians placed a satellite in space before the United States, has so much attention been given to mathematics education. The report, Educating Americans For the 21st Century, states concisely and completely the recommendations of educational experts for the necessary instruction, kindergarten through twelfth grade, in mathematics, science and technology for our country to remain a world leader.

This report by the National Science Board Commission on Precollege Education in Mathematics, Science and Technology is to the American people and the National Science Board of the National Science Foundation (NSF). It provides a, "plan of action for improving mathematics, science and technology education for all American elementary and secondary students so that their achievement is the best in the world by 1995."

The report's main thesis is that the nation is failing to provide its children with the intellectual tools needed for the 21st century. In fact, the formulation of this Commission was a response to criticism of and apparent decline in the schools of America - particularly in the areas of mathematics, science and new technology. With a continuation of the present system, our nation could become a straggler in a world rapidly changing by new technology. The Commission issues a resounding call for a return to the basics, but for the 21st century, the basics include the three R's plus communication, higher problem solving skills and scientific and technological literacy for all students.

Obviously such sweeping changes as recommended by the Commission would have deep and permanent implications for college mathematics education. Before pursuing an examination of these effects, the Commission's report should be examined more thoroughly. The scope of this examination will be limited primarily to mathematics education, although most comments not specifically related to mathematical course content would apply to science and technology also.

Since the late 1960's most students have taken fewer mathematics and science courses. Mathematics achievement scores of seventeen year-olds have dropped steadily and dramatically during the same period. Twenty-five percent of American children don't graduate from high school. Mathematics, science and technology education must shift to center stage for all students. The Commission has seen convincing evidence that all students, without insurmountable learning disabilities, can develop a useful understanding of mathematics if subjects are appropriately introduced and skillfully taught. This thesis implies fundamental changes in both what is learned and how it is taught.

The Commission proposes to institute these changes through:

(1) building a strong and lasting national commitment to quality education in mathematics, science and technology for all students;
(2) providing earlier and increased exposure to these topics;
(3) providing a system to measure student participation and achievement;
(4) retraining, attaining and keeping quality teachers with a strong commitment;
(5) improving the quality and usefulness of the curriculum;
(6) establishing exemplary programs in every community to serve as standards of excellence for every school system to pursue;
(7) utilizing all available resources, such as museums, information technologies, television, etc.;
(8) establishing the costs and devising ways to meet them.

In order to build a national commitment the President should immediately appoint a National Education Council, reporting directly to him, which would identify national goals and necessary changes in mathematics education; develop

and maintain an assessment mechanism; report annually to the American people about progress toward the goals and about exemplary programs; and recommend incentives to encourage state, local and private interest in education. States and local governments should follow this national example with similar actions. Hence a strenghtened commitment at all levels of government to ensure quality education for all American students is required.

By examining American successes in education and the systems of other countries, the Commission concluded that earlier and increased exposure to mathematics is needed. Japan provides a good comparison with our educational system. The Japanese system is committed to universal education; in fact, their system was modeled on ours after World War II. Our best students compare favorably with theirs, but with less than excellent students, Japan is much more successful than the United States, particularly in science and mathematics. Japan's better success rate seems to be a result of more time spent on the study of mathematics and better motivation of students. Japan has 220 days per school year compared with 180 in the United States. In addition, our country has more absences per student. The typical Japanese graduate studies science three times as much as our graduates that elect four years of high school science! Teachers have a much higher status in Japan. 94% of Japanese children graduate from high school compared with 74.5% in the United States.

Turning to an examination of the American successes in education, the Commission concluded that quality teaching and early exposure to mathematical topics are critical. Increased time is required, particularly hands-on experience. The Commission thus proposes that 1000 secondary and 1000 elementary schools be established to serve as islands of exemplary educational programs, with the hope that these schools will serve as models for change across the country. Many such schools exist now with words such as "magnet" or "model"

in their names. These schools have the characteristics mentioned above with the outstanding feature of commitment on the part of all individuals involved.

The Commission believes the teacher is the key to our educational problems in mathematics. However, severe shortages of mathematics teachers presently exist, and many currently teaching mathematics are in dire need of retraining. Current shortages are partly a result of declining numbers of education majors. In 1966 twenty-two percent of entering college freshmen chose education as a major while less than five percent chose education in 1982. The shortage is further increased by the number of mathematics teachers entering industry or business for higher paying positions with more prestige in the community than teaching.

In addition to the shortage of mathematics teachers, there has been a decline in the quality of individuals entering the teaching profession. The SAT scores of students planning to enter education are currently 80 points below the national average. This difference is approximately fifteen percentile points.

The situation is further complicated by teaching being perceived as a low status profession with a poor working environment, low financial rewards and lack of advancement.

In order to improve the quality of teaching and ease the current shortage of teachers, substantial efforts are needed at three levels. Upgrading of skills of current teachers along with improved training of incoming teachers is needed, and "non-traditional" sources of teachers should be obtained in the interim.

To upgrade skills of current teachers, the Commission recommends that NSF establish state-wide or regional teacher training programs using the new information technologies such as telecourses and interactive telecommunication.

In addition, it is recommended that the states develop teacher training and retraining programs with colleges, universities and museums. Further the states should develop regional training and resource centers which would include computer instruction and software evaluation. These centers could serve as the focus for participation of business and government in education.

In order to improve the training of incoming teachers, the Commission makes the following recommendations. Rigorous certification standards must be adopted by the states, while not creating artificial barriers to entry of qualified persons. Elementary teachers of mathematics should have a strong liberal arts background; college training in mathematics sufficient for understanding functions, elementary probability and statistics and the relationships between algebra and geometry; a limited number of effective education courses and practice teaching under a qualified teacher. The requirements for secondary teachers of mathematics should be the same as for elementary teachers except that they should have a full major in college mathematics. Both elementary and secondary teachers should be computer literate. Furthermore, teacher training should incorporate computers and calculators in mathematics instruction. Liberal arts colleges and academic departments need to assume a much greater role in training teachers. Basic education courses should contain current findings in behavorial and social sciences.

In the short run, to ease the mathematics teacher shortage, the present teaching pool can be enlarged by utilizing the staffs of industry, universities, military and government employees and retired scientists. Local systems should take action to facilitate the entry and classroom training of such special teachers.

In order to make the classroom a rewarding place to work, teacher compensation, as well as the classroom climate, must be improved. In purchasing power,

teacher salaries are fifteen percent below the level they were during the 1970-71 school year. Methods must be found to reward excellence in teaching and provide opportunities to move up a status ladder without leaving the classroom. Salary levels should be adjusted if the length of a teacher's commitment to the schools is increased. Other devices to be explored include differential pay, merit pay and possible reimbursement for in-service training, curriculum development and summer employment by industry. The use of computer management techniques to relieve mathematics teachers of excessive administrative burdens and to make more time available for teaching should be pursued.

To improve the classroom climate, the Commission recommends that there be greater administrative and parental support of discipline and attendance; fewer classroom interruptions and higher academic standards; and provision of needed equipment, materials and specialized support staff. Social promotions should be curtailed. Regular attendance should be required for full credit. Students need to be more involved in their education. The focus should be on high achievement in academics. Since 1969 student enrollment in algebra I has declined from 76% to 64% while, during the same period, enrollment in driver's education has climbed from 0.3% to 59%.

In order to improve what is taught and learned, the Commission makes the following recommendations. First of all, increased time on mathematics is mandatory. A full hour daily on mathematics in elementary is necessary. In 7th and 8th grade a full year of mathematics should be required. There should be statewide performance standards and strict high school graduation requirements, along with stringent grade promotion requisities. By September 1, 1985, three years of high school mathematics, including one year of algebra, should be required of all students. One semester of computer science should also be required. The colleges meanwhile should phase in higher college entrance

requirements, which would eventually include four years of mathematics (with two full years of algebra) plus probability and statistics. Counselors should be obligated to inform students of these rigorous requirements and attempt to recruit minorities and women to scientific courses of study.

To improve the curriculum there would need to be a focus on mathematics for all students, not just pre-professionals in science and mathematics. Industry and business spokespersons have indicated the need for a strong general education rather than one directed toward specific job-related skills, since the nature of the work in scientific and technological fields changes so rapidly.

The Commission states that instruction in grades K-8 should produce the following results:

- -Comprehensive understanding of and facility with one-digit number facts, place values, decimals, percentages and exponential notations.
- -Skill in informal mental arithmetic, estimation and approximation.
- -Ability to use calculators and computers selectively.
- -Basic understanding of elementary data analysis, simple statistics and probability, and fractions.
- -Ability to use some algebraic symbolism and techniques.
- -Thorough understanding of arithmetic operations and knowledge of when each should be used.
- -Development of problem-solving abilities.
- -Understanding of the relationship of numbers to geometry.
- -Development of an intuitive geometric understanding and ability to use the mensuration formulas for two- and three-dimensional figures.
- -Ability to use the concepts of sets and some of the language of sets as tools, not end goals.
- -Understanding of elementary function concepts including dynamic models of increasing or decreasing phenomena.

Finally, significant exposure to computers by the 4th grade is advocated.

At the secondary level certain topics in the traditional mathematics

sequence have little modern-day importance. For instance, geometry should not be isolated into a year long course. Instead it should be integrated over several years with other mathematics courses. "Discrete mathematics, elementary statistics and probability should now be considered fundamental for all high school students." The report describes discrete math as basic combinatorics, graph theory and discrete probability. Furthermore, modern technology dictates new approaches to the teaching of mathematics. Symbolic manipulation systems for computers will allow students to do symbolic algebra at a much more sophisticated level than currently is the practice. Computer graphics and the coming interactive videodisc systems can enhance the presentation of many topics. Algorithmic thinking should be stressed as a part of all problem solving while student data-gathering and exploration of mathematical ideas can enable students to learn by discovery.

Specific secondary content recommendations of the Commission:

Algebra for all students:

-Ability to recognize basic algebraic forms and know how to transform them into other forms.

-Understanding of the logic behind algebraic manipulations.

-Skill in solving linear equations and inequalities.

-Skill in solving quadratic equations.

-Ability to graph linear and simple quadratic functions and use these in interpreting and solving problems.

-Familiarity with permutations, combinations, and simple counting problems.

-Knowledge of relations and functions.

-Development of problem-solving abilities.

Further algebraic topics recommended for students exhibiting interest in and talent for mathematics:

-Skill in solving higher degree equations and inequalities.

-Knowledge of various types of functions including polynomial, exponential, logarithmic and circular functions.

-Ability to graph higher degree functions.

-Familiarity with the binomial theorem.

-Skill in solving trigonometric, exponential and logarithmic equations.

-Familiarity with arithmetic and geometric sequences and series.

-Knowledge of simple matrix operations and their relation to systems of linear equations.

-Skill in operations with complex numbers.

Geometric topics to be covered by all students (integrated into the 8th and 9th grade programs):

-Ability to think logically.

-Ability to work through short sequences of rigorously developed materials while de-emphasizing column proof.

-Knowledge of two- and three-dimensional figures and their properties.

-Ability to think in two and three dimensions in terms of congruence and similarity.

-Ability to use the Pythagorean theorem and special right triangle relations.

-Understanding of algebraic methods in geometry and analytic geometry; and vector algebra, especially in three dimensions.

-Familiarity with computer graphics packages to get a visual sense of geometric concepts and transformation.

Other mathematics:

Instruction should be designed to achieve the following outcomes:

-Understanding of elementary statistics (data analysis, interpretation of tables, graphs, surveys, sampling).

-Knowledge of computer science (programming, introduction to algorithms and iteration).

-Familiarity with the philosophical basis of calculus and understanding of the elementary concepts of the subject (e.g., rates of change, intuitive ideas of limits).

The implications of Educating Americans For the 21st Century are far-reaching at the college level, particularly for the two-year college. If the American elementary and secondary schools are able to attain any significant part of the goals as set forth in this report, both improvements and problems will be the result for the colleges of our nation.

A major advantage to colleges of the Commission's recommendations would be the resulting improvement of teachers of mathematics at the elementary and secondary levels. The mathematics teachers, that emerge as a result of the Commission's goals being reached, will be better trained in mathematics and computer science. They will enjoy higher status in the community as a result of being teachers. They will earn more money and will not see themselves in a dead-end profession, with no chance for advancement. Presumedly these teachers will have a positive attitude toward themselves, their chosen profession and their students.

As a second major improvement, entering college freshmen will be of much higher quality in mathematical ability. Colleges can expect more and better prepared students to take mathematics courses. These students will have benefited from being taught by better prepared mathematics teachers. They will be accustomed to rigid attendance standards and passing a class only if they have attained a satisfactory level of competence in the subject matter. These students will believe that science and mathematics are a valuable part of each individual's educational background and a necessary part of preparing for future employment. They will expect to spend a large share of their collegiate academic time in the pursuit of learning mathematics. These students will have been introduced to at least one computer language and will have seen and/or used many computer software and graphics packages in the learning process.

While teaching these students will certainly be an advantage for the

college professor, there will be problems. With more students, having better training in mathematics than their predecessors, seeking entrance at the college level to scientific and technical professions, the enrollment in mathematics classes would increase, perhaps dramatically. Consequently, there would be a need for more college faculty in mathematics, more space and a larger budget for college mathematics departments.

Since there is already a national shortage of mathematics teachers, a demand for more college mathematics professors would need to be met utilizing the same techniques suggested in the Commission's report for reducing the shortage at the secondary level. However, at the college level, professors are required to possess graduate degrees in academic subject matter fields. Hence, there would be a need to encourage more persons to study mathematics at the graduate level. If, as the Commission recommends, the classroom becomes a more rewarding place to work and if compensation for college professors can be improved as well, then hopefully the need for more college mathematics professors will not become a dire problem.

There is a definite trend at two-year colleges to replace retiring faculty and to staff new sections with part-time employees. While many of these part-time employees are excellent professors and well-qualified to teach mathematics, the qualifications for part-time employees are frequently lower than for full-time employees. Furthermore, many of these professors have full-time employment elsewhere. Obviously few of them can have the commitment to the institution and program of the college where they are employed part-time that a full-time faculty member should have. Neither can they be involved with curriculum development, student problems and other aspects of a full-time faculty member's obligations as completely as is desirable. Part-time faculty usually receive little opportunity for or encouragement of professional development. Communi-

cation with them is frequently lacking, and evaluation of their performance and suggestions for improvement may be scarce or non-existent.

The space and budgetary problems that additional college mathematics students cause, might be solved by shifting revenues from college programs which lose popularity as the emphasis swings toward mathematics and science. In any event, the solutions to these problems would lie with college administrators in the governmental and political arena.

The Commission states, "Most of the Nation's 200,000 secondary mathematics and science teachers...require additional training because of the rapid development of new knowledge in mathematics and science...." Two-year college mathematicians fall into the same category. Many current two-year college mathematics professors are in need of either training in or a review of computer technology, discrete mathematics, statistics and algorithmic thinking.

Many two-year college mathematicians have resisted learning about computers, fearing that they might be required to teach computer science rather than mathematics, lacking either the time or financial resources to train in these areas themselves or resisting the infusion of computer science into the mathematics curriculum. Many professors also would need training with computer software and graphics packages that the Commission recommends be used. While most two-year college mathematics professors have had courses in statistics, new uses of computers have altered dramatically both the approach and scope of the course. Consequently, training is needed in this area.

As stated earlier, the Commission has recommended that discrete mathematics be considered fundamental for all high school students. The Commission indicates that discrete mathematics consists of basic combinatorics, graph theory and discrete probability. Currently at the college level, there is uncertainty about the contents of a discrete mathematics course. Such classes

are appearing at two-year colleges for the first time. Certainly efforts are necessary to define more precisely the contents of these courses, and many two-year college mathematics professors need training or review in these topics.

The solution to the problem of renewal of skills for college mathematics professors lies in making available to the two-year college mathematics faculty the same opportunities that the Commission is recommending to the nation for K-12 mathematics teachers.

Two-year college mathematicians should be allowed to use the programs and services which NSF has begun to offer for K-12 teachers. It appears that all of the current funding from NSF in mathematics is in the area of K-12 or research. There is a definite need for NSF programs in mathematics appropriate to the two-year college. Such programs are certainly appropriate to the Commission's desire to extend mathematical opportunities to all students since the National Bureau of Statistics reports that more than 40% of college students are enrolled at two-year colleges.

Furthermore, recently announced NSF programs in mathematics curriculum development for K-12 should be extended to include the two-year colleges, as should any other curriculum development programs instituted as a result of the Commission's recommendations. Since currently two-year colleges teach all of the secondary mathematics curriculum to large groups of remedial students, there is a need to reorganize and develop that curriculum as well. If geometry is to be merged into the basic mathematics and beginning algebra classes, for example, the two-year college curriculum will need a similar change.

Two-year college mathematics professors should be entitled and encouraged to utilize the services of the various regional training and resource centers

that are recommended in the Commission's report. The dissimination of information from the evaluations of the various programs that are instituted as a result of the Commission's report should also be made available to the two-year colleges. Of particular importance would be information regarding the 1000 model secondary schools to be instituted as a part of the Commission's recommendations. Hopefully these schools will serve as catalysts for change in approach at the two-year college where all of the secondary mathematics curriculum is currently taught to students whose exposure to these topics is either outdated or inadequate.

The Commission recommends that, "The professional societies in mathematics ...should play an active role in curriculum development, review and revision." These activities by the American Mathematical Association of Two-Year Colleges (AMATYC), Mathematical Assocation of America (MAA) and National Council of Teachers of Mathematics (NCTM) should be extended to include the two-year college.

Programs to recognize excellence in mathematics teaching, such as NSF recently instituted, should be extended to include two-year college professors of mathematics. The various professional mathematics societies could develop ways to recognize excellence in mathematics education at the two-year college as well.

The Commission indicates that colleges should phase in higher entrance requirements, which would eventually include four years of mathematics (with two full years of algebra) plus probability and statistics. Many two-year colleges are committed philosophically and perhaps even legally to "open door" policies, whereby they are required to admit any person of a certain age to college classes. These policies do serve to execute one aspect of the Commission's report - to provide the opportunity for mathematics education to all persons. Such a drastic change in entrance requirements would be inappropriate for such "open door" colleges. However, such colleges, could consider instituting a policy of

requiring successful completion of certain remedial classes for students deficient in secondary course work before admitting them to full stature in the college.

Few could deny the need for a general reawakening in America of the importance of education and the necessity of striving therein for more than mediocrity, particularly in mathematics and science. The Commission's report sets forth worthy goals in these areas for elementary and secondary education. Only time will tell whether these goals are attained or fall by the wayside to decay in the dust of neglect. One thing is certain - without action and commitment on the part of mathematics and science educators at all levels, the Commission's plan will fail. The two-year colleges must respond now with a plan of action to improve the achievement of their students in mathematics and science. Efforts will be mandatory on many fronts. The various professional mathematical societies can be a key influence in providing the leadership for change at the two-year college. Acting through the College Board of Mathematical Sciences (CBMS), they, along with the other scientifically oriented societies that belong to that organization, can pursue the solutions to what may well some day be called the two-year college dilemma. With a concerted, coordinated effort on the part of the leadership of these organizations to awaken government, business, industry and our colleagues, the two-year college can hope to meet the challenge of Educating Americans for the 21st Century.

by Professor Karen Sharp
Mott Community College
Flint, Michigan

Summary of Mathematics Course Content

Educating Americans for the 21st Century

In order to improve what is taught and learned, the Commission makes the following recommendations. First of all, increased time on mathematics is mandatory. A full hour daily on mathematics should be required. There should be statewide performance standards and strict high school graduation requirements, along with stringent grade promotion requisites. By September 1, 1985, three years of high school mathematics, including one year of algebra, should be required of all students. One semester of computer science should also be required. The colleges meanwhile should phase in higher college entrance requirements, which would eventually include four years of mathematics (with two full years of algebra) plus probability and statistics.

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